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# SUSTAINABLE DEVELOPMENT OF GROUNDWATER RESOURCES: LESSONS FROM AMRAPUR AND HUSSEINABAD VILLAGES, INDIA

**Tushaar Shah**

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**Papers in this set:**

90/3b Interactions Between Technical Infrastructure and Management by L Horst
90/3c Irrigation Allocation Problems at Tertiary Level in Pakistan by M Akhtar Bhatti and Jacob W Kijne
90/3d Sustainable Development of Groundwater Resources: Lessons from Amrapur and Husseinabad Villages, India by Tushaar Shah
90/3e The Politics of Water Scarcity: Irrigation and Water Supply in the Mountains of the Yemen Republic by Linden Vincent
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# SUSTAINABLE DEVELOPMENT OF GROUNDWATER RESOURCES: LESSONS FROM AMRAPUR AND HUSSEINABAD VILLAGES, INDIA[1]

**Tushaar Shah**

**Contents** **Page**





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# SUSTAINABLE DEVELOPMENT OF GROUNDWATER RESOURCES: LESSONS FROM AMRAPUR AND HUSSEINABAD VILLAGES, INDIA[2]

Tushaar Shah

## 1 INTRODUCTION

In a workshop on groundwater management at the Institute of Rural Management (IRMA) held in March 1989, Rolf Mueller, one of the workshop participants, called groundwater a "free, but scarce" resource: Because it is free, it is used freely where there are no rules which define who can take how much of this precious resource, and because it is scarce it tends to get exhausted with rising pressures of demand. As a result, in many areas, conditions of over-exploitation of groundwater aquifers have resulted in serious ecological consequences.

In such areas, groundwater management regimes can go in either of two ways. Firstly, the groundwater balance may be disrupted and (the farming system) may fall to a new equilibrium at lower levels of output and incomes. Alternatively, some system of rules may be accepted by groundwater users that so regulates each user's behaviour as to begin a new, sustainable, community-based management of the resource.

A good part of coastal Saurashtra, Gujarat, as indeed many other regions in the country, has in the last 15 years gone the first of these two ways. In thinking about resource management issues in these areas, the recurrent question is: "Are there ways village communities can be helped consciously to move towards the second way and develop ***self-correcting mechanisms*** (SCMS)."

The Aga Khan Rural Support Programme (AKRSP), India, has been exploring this question in several villages of Junagadh and Surendranagar districts of Saurashtra, Gujarat state. This report describes the results of work done by Daniel Bromley and the author in two of these villages,

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Amrapur and Husseinabad, to examine local level planning and resource management options available for NGOs like the AKRSP to experiment with in such areas.

Amrapur and Husseinabad represent the conditions that obtain in much of coastal Saurashtra which, until a decade ago, was so green and agriculturally prosperous as to be popularly called 'Lili Nagher' (Green Creeper). The intensive groundwater irrigation which developed with the onset of the modern pumping technologies in the mid-1950s was central to this rural prosperity. Under supportive government policies which made subsidies and credit freely available for intensive private groundwater development, motorised wells expanded rapidly, especially after 1960: In many areas, water-loving crops such as sugar cane, banana, fruit orchards, etc, began to replace traditional crops. Three crops a year became quite common with the help of motorised wells. The amount of water lifted from the coastal aquifers between any two monsoons increased over 10-15 times. As a result, by the late 1960s, the fragile coastal groundwater balance was disrupted. In inland areas, such as Amrapur, separated from the sea by a natural ridge, wells began to dry up in late rabi (January-March) and summer seasons, as happens in the hardrock areas of the south-Indian peninsula. More seriously, in low-lying areas closer to the sea, such as Husseinabad, large and increasing areas experienced intrusion of sea water into their wells.

The socio-economic backlash that salinity ingress created in the area and the misery it caused, especially among the poor, have been documented by several authors (Shukla 1985, Menon 1985, Shah 1988). The government responded to the challenge by mounting a programme to construct physical structures, check dams, bandharas, and tidal regulators with the aim of increasing fresh water recharge and reducing intrusion. It was soon found that farmers quickly used up the 'slack' so created by a free 'open access' resource. This response, and the need for a strategy to cope with intrusion, emphasises the need for a more effective and sustainable common property management of the aquifer at village or sub-regional level.

The main purpose of our fieldwork was to explore the possibilities of this happening, and to understand the conditions under which the present open access groundwater use regime could be replaced by a better regulated management regime. Section 2 of this report describes our experience in raising some of these issues with the people of Amrapur where conditions are somewhat better than in Husseinabad, and the scope for cooperative management strategies are good. Section 3 presents a somewhat speculative analysis for Husseinabad; this analysis offers some guidelines and ideas for action but falls quite short of an action plan. Section 4 is essentially an apology for this inadequacy and argues strongly for experimentation and adaptation through a flexible plan of action that involves the two village communities in planning and managing the use of their groundwater resources.

## 2 AMRAPUR

### 2.1 Village Profile and Social Structure

Amrapur is a largish multi-caste village in the Malya taluka of Junagadh district. Ismailies, Karadias, Sagars, Lohanas, and lower-caste communities, including Harijans, Rabaris, Bharwads, Mumnas, and Khat Darbars account for over 95% of the village's 2000 strong population.

Farming, dairying and trade in agricultural outputs and inputs are major sources of incomes. Amrapur is the hub of a major trading outfit serving 17 neighbouring villages, controlled by the Lohanas of Amrapur. In agriculture, the bulk of the surpluses are generated on irrigated lands; over half of the irrigated land in the village is owned by Ismailies who account for 25% of the households; Karadias and Sagars claim the bulk of the remaining irrigated land. About 60-70% of the land has some irrigation facilities; almost all Sathani land and the land belonging to marginal farmers has no irrigation and can be used only for the kharif crop. Some Harijans and Rabaris got Sathani land from the government of Gujarat in 1969, however, this land used to be government wasteland of poor quality, and almost all of it is un-irrigated and therefore useful only for a kharif crop[3]. The land holdings of those who own wells are quite large ranging from 6-32 acres with a modal value of around 8 acres. For non-well owners (whom we did not get to know so well), the modal value of land holding would most likely be around 2 acres.

### 2.2 The Origin of the Problem

Open, dug wells are the primary source of irrigation in the village; some farmers also lift water from river Madherdi and river Vrajmi when they have water. There are about 320 wells: over half of these use electrically powered pump sets, the remaining use diesel engine driven pumps. Almost

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[3] *The seasons used in Gujarati cropping are:*
*Kharif - during the southwest monsoon, July-September;*
*Rabi - withdrawal of southwest monsoon, October-January;*
*Summer - February-May. (editor)*

all the farmers we talked to used 5 hp motors or engines; 7.5 hp motors were exceptional. Well water has caused particular shifts in rabi cropping activities.

The monsoonal rainfall in the area ranges between 750-1000 mm. Groundnut continues to be the most kharif important crop despite extensive access to well irrigation. In more recent times, a rabi wheat crop has become common for most farmers with well irrigation. In summer, a small area is normally planted with sorghum fodder or lucerne. Some farmers have also converted a part of their farm into a mango-cum-coconut orchard; these are quite intensive in water consumption.

At the end of the 1988 monsoon, which was one of the best the area received in decades, all wells in Amrapur were full and many continued to yield long after the last rain. Even at the beginning of February, there was water in the Magherdi river. Encouraged by this, there was extensive sowing of rabi wheat by the farmers. In addition, given high prices available, many farmers still with water in their wells at the end of rabi season decided to plant sizeable areas with summer groundnut.

Most of these farmers ended up losing heavily and regretting their decision to plant an additional crop. Many wells ran dry in the middle of rabi; as a result, rabi wheat took heavy losses for the want of last two or three waterings. Of the remainder, most well owners ran out of water in the mid-Summer and had to either write off the crop fully or do with very low yields of 150-200 kg per acre, despite buying water at Rs 200[4] or more per bigha watered from those lucky few with wells still yeilding water.

Farmers saw the problem as insufficient harvesting of water; their preferred solution was to build more check dams to improve rainwater storage. Barber, however, came to a somewhat different conclusion and saw the problem essentially as the inability of the farmers to foresee the possibility of the wells drying up and incorporating such fore-knowledge into their planning and decision making.

## 2.3 Aquifer Characteristics

Amrapur village is in a valley and is surrounded on all the sides by elevated plain land and hillocks. The Magherdi, a seasonal river, cuts

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[4] *In December 1990, US$ 1 = 17.8 rupees*

*2.5 bighas = 1 acre.*

across the village and is met by three small rivulets called Vrujmi, Rakhodio and Jarado. All these then flow into Dadhichi reservoir where water is stored to provide piped drinking water to several villages of Mangarol taluka.

The entire valley constitutes the catchment area for the aquifer, and the rivers bring water which recharges the aquifer. The AKRSP has built two check dams which further increase the recharge and storage (see Figure 1). Check dam 1 was ready by the 1988 monsoon and brought considerable benefit to the wells.

Our initial hypothesis was that the village is underlain by a 'trap'[5] aquifer whose boundaries coincide with the village boundaries. The aquifer is like a bowl so that the wells located at the center will always have more water and for longer periods than those at the rim. However, with the river, the bowl has a hole in the bottom, as it were, so there is no incentive to conserve water since water not used is lost. Thus, the aquifer and the wells provide no inter-year storage. The key needs are: (a) to capture as much of the rainfall and river recharge as possible; (b) to schedule its utilisation so that water loss via the river from the village catchment is minimised; (c) to ensure that all water is used up before the next monsoon; and (d) to organise the most efficient and equitable use of the available water through a suitable community groundwater management system.

### 2.4 Interviews with Farmers

We visited about 30 wells and had discussions with some other well-owners. We visited wells in all major topographical zones across the village catchment; for instance, we met well owners in the valley and along the rim, within the river bed, near the river and away from it; near the check dams and away from them; near the Dadhichi reservoir and away from it, etc. Contrary to our starting thesis many wells on the rim had good recharge even at the end of Summer, with some being able to pump almost continuously. On the contrary most wells in the center, including many near the river and the dams and one or two within the river bed had no water at all. Indeed no pattern seemed to emerge which would explain why some wells had water and others did not. We visited wells less than 50 feet apart with one having plentiful of water and the other completely dry suggesting independent sources of recharge for such wells.

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5 *'Trap' rocks derive from extrusive volcanic activity.*

In contrast, in some areas, there was a major element of well-interference among neighbouring wells.

We inquired if the farmers had a theory of their own to explain how the aquifer of the village behaved. Farmers operate under conditions of uncertainty right from the point of decision about digging a well. Striking water at the first attempt was uncommon; we met a farmer who had spent over 100,000 Rs digging five unsuccessful wells. Even if one struck water, there was no way of being sure of yeild across the year. If over years of differing rainfalls, one developed some working knowledge of the well's behaviour, that too could be invalidated as more new wells come up in the neighbourhood, or check dams are built, and more deep bores for water supply are sunk behind the Dadhichi tank which would 'steal' water from underneath the village wells.

Farmers are found to respond to this uncertainty in a variety of ways. Most make sure that they make several vertical and horizontal bores[6] at the bottom of their dug well so as to capture all possible sources of recharge. Those who have resources dig two or three productive wells at different locations in their farms; in a few such cases, we found that if one well did not have water, the other did.

Each farmer seemed to have identified, from experience, some kind of 'leading indicators' which help them to predict the behaviour of their wells. For instance, a series of well owners we met along the river suggested that as soon as the river begins to dry up and water level drops below a certain level, they know that it will not be long before yields decline. Farmers, therefore, begin to pump simultaneously to claim as much of the remaining water as possible, presumably wasting a good deal of it. This 'competitive pumping' must, to a great extent, hasten the pace of depletion of the aquifer. A power tariff linked to horse power accompanied by a reasonably good electricity supply has further encouraged this behaviour.

Though our interviews were unstructured, we collected for each well information on (a) diameter of the well in feet, (b) depth to the bottom and the number of vertical and horizontal bores inside the well, (c) current depth to the water level in the well, (d) hours of pumping needed to empty the well, (e) hours taken for the well to refill. These unstructured interviews also provided us some clues about the pumping behaviour of well owners, especially towards the end of rabi and through the summer.

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[6] *2-4 being common, but several having more than 5.*

Normally, during and after a good monsoon, most wells can be pumped continuously since the rate of recharge to the wells far exceeds the rate of withdrawal. In some wells, the water table would not fall at all, while in most it would fall but only by a few feet even after a fully day's pumping and would be restored in a few hours. From mid-Rabi onwards this situation would begin to change. The water table would fall by several feet after a day's pumping. In summer, continuous pumping becomes impossible in most wells; our interviews suggested that the well would be emptied after pumping of between 10 minutes to six hours depending on the well; and it would take between 6 and 48 hours before the well can be pumped again for the same duration.

## 2.5 Individual and Group Strategies

From our discussions with farmers, there seemed four distinct conditions of recharge in the wells, with two which 'continuous pumping' is possible. In the first of these, the rate of recharge clearly exceeds the rate of discharge so that the water level in the well is not affected at all by pumping; in the second, the rate of recharge is marginally less than the rate of discharge so that it takes several days and nights of continuous pumping before the well begins to empty and pumping has need to be discontinued to allow recharge.

The remaining conditions are 'wait and pump' phases ('uteri uteri' in local language) in which the rate of recharge is much less than the rate at which water is extracted. In the third phase, the well can be pumped throughout the day and will get recharged during the night; in the fourth phase, recharge becomes so small that the well can be pumped only for a few hours, often for a few minutes, before the well gets emptied and needs a day or several days to recharge. In these later two phases of 'wait and pump', water use programming becomes important. It is also largely during these phases that farmers become aware about the well-interference externally and practice 'strategic behaviour'. All the wells in the village can be classified according to their conditions of recharge at any time point. A model for pumping regimes in these four recharge phases is given in Box 1.

**Box 1:**

Given the location of a well with a recharge source, the static storage in the well S can be written, in a simplified form, as

$$S = \pi . (d/2)^2 . h$$

where d = diameter of the well below the highest recharge point and h = H* - HO, with H* = depth to the basalt layer (i.e. weathered thickness), and HO = depth to the water level in the well.

If x defines the rate of discharge of the pump and r is the rate of recharge both in cubic feet per second, then the hours for which the well can be pumped continuously can be written as [S/(x-r)]/3600 and the time the empty well will take to recharge to the pre-pumping water level will be (S/r*3600).

We can also define the define the pumping regimes in relation to these four recharge conditions:

| | |
|---|---|
| Phase 1 | r>>>x : continuous pumping |
| Phase 2 | x>r ; but [S/(x-r)]/[3600x24] = several days |
| Phase 3 | x = (1.5 to 2.5)r and/or S is large; so that [S/(x-r)]/3600 = 8 to 12 hours |
| Phase 4 | x = (10 to 30)r and S is small; so that [S/(x-r)]/3600 = 0.5 to 3 hours |

The options available to individual well owners, especially in phases 3 and 4, and to the community as a whole are:

(a) increase the the rate of recharge to their wells and/or storage of their wells below their recharge zones;

(b) and/or adapt their cropping plans so that they can do with less water especially in rabi and summer thereby reducing the required rate of pumping;

(c) develop better understanding of the behaviour of their wells or improved crop planning;

Some of the ways in which these can be done are presented in Box 2.

**Box 2: Individual and Group Strategies for Groundwater Management**

| | Individual Strategies | Group Strategies |
|---|---|---|
| 1. *increase r, the rate of recharge;* | farm pond as recharge source; exploit deeper aquifer by more bores; dig larger diameter well below the recharge zone; | more check dams and percolation tanks; reduce pumping from the Dadhichi tank; |
| 2. reduce x, the pumping rate; | reduce summer cropping; use piped conveyance and sprinklers; | group decision on extent and mix of summer cropping; cooperative exploitation of groundwater; |
| 3. better crop and water use planning; | better understanding of one's well and its interaction with the aquifer; | better understanding of the interaction between wells; efficient water markets; |

There are large variations in the individual responses to the water conditions. Kamabhai, an Ismaili small farmer, for example, followed a two-pronged strategy which was different from other farmers. Most well owners have 2-4 bores at the bottom of the well; Kamabhai made 15, most of them horizontal, to capture greater recharge. Whereas most wells are large in diameter at the top and become progressively smaller as they go down, Kamabhai's well was much bigger inside (especially below what he thought were the recharge points) than at the top. Kamabhai's well could be pumped continuously for days when we visited it and is well known in the village as one of the more productive and dependable wells and he attributes it to the two changes he made in the design.

The explanation he offered made sense in terms of our simple analytical framework of recharge conditions; the static storage S is largely determined by the recharge rate and the storage space available below the points where the well receives horizontal recharge. Since his well affords greater storage during the night when pumping is discontinued, he can pump through the day uninterrupted. He also argues that one of the problems of the wells which reduce to 'wait and pump' status early in the summer is that they get smaller in area as one goes down and therefore offer less scope for storage to build up when the well is not pumped.

Another unusual decision Kamabhai took was to leave a part of his farm un-irrigated and intensively apply his scarce water to only a part of his land which he has converted into an orchard. Kamabhai was happy with the outcome and his orchard looked quite good. Everyone else was applying water thinly over extensive areas and it would be worthwhile for the AKRSP to explore which of the two approaches is superior. We felt that studying the ways of enterprising and wise farmers like Kamabhai might provide elements of individual strategies which, if presented and extended appropriately, might help to improve the responses of other farmers.

For viable group strategies, the most important condition is a shared and improved understanding among well owners of (a) aquifer conditions, (b) interaction between one's well and the aquifer, and (c) interaction among different wells. In the context of Amrapur, creating such understanding would imply, among other things, mapping of all the wells over the year according to the four sets of conditions (Phases) discussed earlier. Such mapping would then form the basis of all discussion, extension and negotiations on water use strategies within the village. The project is now studying information exchange whereby farmers not water information on for use and submit them to a village-level organiser in return for a periodic analysis of their situation. The organiser can in turn collate this information on a catchment basis, for better information, and to initiate 'historical data collection and advice' records likely to be useful for community water strategies.

# 3 HUSSEINABAD

## 3.1 Village Profile

Husseinabad village of Mangarol taluka ahs a similar population to Amrapur, about 2000, but has just over 1200 acres of cultivated area. Unlike Amrapur, Husseinabad is predominantly Muslim. The village is situated on the bank of the river Noli. The river is seasonal and the government has built a series of dams to conserve and store water just before the river flows into the sea. The Sheikh had built a large dam near the neighbouring village of Sheikhpur. From the reservoir of the dam, a canal was built to transport water to Husseinabad. The village elders informed us that since before Independence until 1965, the canal has been used by farmers for irrigation. Over the years, however, due to siltation, water has become less able to flow easily into the canal. In 1967, the government decided to repair and enlarge the dam, and the government installed a 100 meter pipeline to convey water to the canal. This fix never worked and after the renovation of the dam, whatever little water earlier flowed into the canal stopped.

Mango and coconut orchards dominate land use in the village and are a major source of income. Some crops are grown too. In kharif, most farmers grow groundnut; in rabi, many grow wheat and mung[7]. Wells are the only source of irrigation although on the river bank, a few farmers are able to pump water directly from the river when it has water.

## 3.2 Salinity Problem

Unlike Amrapur which is over 10 km from the sea and at a higher altitude, Husseinabad is much closer to the sea. As a result, while the three year drought that lasted till 1987 left Amrapur with only a relative water shortage, it left Husseinabad in deep trouble. A third of Husseinabad's wells located on fields closer to the sea became saline. Except for some days during the rains, all water pumped from these wells is now unfit for irrigation. The fields in these parts have suffered major yield decline in all crops except kharif groundnuts. Within the next two or three years, it will no longer be possible to irrigate crops on these lands. Coconut yields have declined by 30-70%, and the poorer quality of cocomunt produced commands lower prices.

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[7] *Mung is a short duration pulse crop.*

The conditions for the farmers located in the saline zone, both large and small, is desperate. We met two owners of large orchards close to the sea some distance from Husseinabad who earn most of their income from coconut and whose earnings have, over the past decade, declined to 10 - 20% of their pre-salinity levels. We also met several small holders who were in a more miserable state. One young farmer had been forced to sell off his assets including his buffalos and a pair of bullocks.

## 3.3 Three Zones

These farmers are located in that part of Husseinabad where groundwater and land have become fully saline. Somewhat further inland is another distinct zone where well water has just begun to turn saline, but where salinity levels are still low, and well water can be used for irrigation. Soils in this zone have not been affected by salinity. However, it is commonly understood that with another drought year or two the saline zone will engulf these lands.

The most inland areas, are still unaffected by salinity. The wells here have fresh water during and after the monsoon, and well into the rabi and summer seasons, and the problems are water scarcity, not salinity. Rough estimates from a group of well owners suggest that about 50 wells are in the saline zone close to the sea, some 100 are in the middle zone with mild salinity levels and another 100 are inland and have still not been significantly affected by salinity.

The quality of water and its quantity are inversely related in Husseinabad. In the saline zone, where water has high salinity content, the wells abound with water. As one moves inland, the water quality improves but the well yields, at least at the time of our fieldwork, declined. If the record of other such villages in the area are any guide, in the next few years all of the village will suffer from acute salinity problem. Barber's view has been that the salinity can be pushed back and the productivity of the lands restored completely over a period of some 30 years but only if all well owners restrict pumping of wells to fresh water recharge only.

## 3.4 Farmer Responses on Restricted Pumping

We asked villagers what could be done to retrieve the situation. The first stock answer received was that only the government could do something about it. All feasible solutions were those linked to increasing the importation of fresh water, and most thought renovation of the canals to bring Noli water to the village to be a priority. In our discussions with well owners from all three zones, we explored the feasibility of controlling water abstraction from wells. It emerged that it was highly unlikely that well owners will individually restrict pumping of their wells to prevent or reduce salinity. Those in the safe zone are certain that wells will soon become saline regardless of how much they themselves restrain pumping if others do not restrict pumping as well. Farmers in the saline zone, who are desperate, are just not interested in solutions that take 30 years to produce results. In any case, not one of some dozen well owners we met from different zones, including a group of highly enthusiastic, young farmers, seriously believed that self-regulation or, indeed, any demand-side solution could be feasible and stable unless introduced in conjunction with an effective supply side intervention.

### 3.5 Transport of Water from Outside

Many well owners in the middle zone with resources have explored quicker private supply side solutions. There is already a water market of sorts in which farmers in the saline and the middle zones buy limited amounts of water from well owners inland. These transactions are highly personalised; prices charged vary a great deal (from Rs 2/hour to Rs 8/hour), and water is conveyed through open field channels with huge seepage losses. One older well owner attributed highly wasteful water use to the imposition of flat rate power tariff and an abundant power supply.

Some farmers in the saline and the middle zones have gone far inland to neighbouring villages, bought small pieces of land at exorbitant prices from private farmers just to sink a well and laid long pipelines to transport water to their fields in the saline zone. Hassanbhai, one such farmer, paid Rs 6000 for a one guntha plot (1/40th of an acre) to dig such a well where the market value of irrigated land is Rs 40-50000 per acre. In profiteering from land sales for wells, inland farmers are imposing a high potential cost on their own resource since, if this trend gathers momentum, it must either result in progressive spread of salinity in inland areas and the depletion of the inland aquifers.

There are elaborate contracts, formal and informal, in laying pipelines for long distances (1 - 3 km) to transport water. If the pipelines pass through government lands, special permission has to be secured and rent paid. If the pipelines pass through private fields, consideration has to be offered normally in the form of assured irrigation service. In one such case that we observed, the well owner had to offer 12 hours irrigation every week at a price which was slightly below the market rate. In one case, the farmer with his field under which the pipeline passed broke off from the group and dismantled the pipes passing from his field, thus cutting the supply to farmers further away from the well.

## 3.6 The Lohej Cooperative

One of the best known efforts to transport fresh water in to saline zones is offered by the Lohej Irrigation Cooperative in Mangarol taluka which transports water from Kantasa village along a 10000 ft pipeline to serve 150 members of the cooperative. Lohej became saline in the 1960s. Arjanbhai, the village Sarpanch[8] at that time, devised the scheme and secured government assistance for the Rs 1.5 lakh project. In 1978, when the first well turned saline, he got another grant to go further inland and sink a second well in Kantasa village. The old well continues to function, although it can be pumped for fresh water only during kharif and rabi. A secretary, a water clerk and two machine drivers constitute the team paid by the cooperative to manage its affairs. The cooperative has also invested in a tractor which it hires out to members as well as to non-members.

The area served by the system has declined by half since 1978. As soils become more saline, farmers need more fresh water to flush the salts out. The area served in a typical year recently has been as follows:

**Box 3: Area Irrigated by the Lohej Irrigation Cooperative**

| **Season** | **Main Crop** | **Area Served Acres** | **Pumping Hours** |
|---|---|---|---|
| Kharif | groundnut | 120 | 1200 hours |
| rabi | wheat | 40 | 2000 hours |
| summer | millet | 40 | 2400 hours |
| Total | | 200 | 5600 hours |

Only a fraction of the village's farm households are members of the cooperative and the cooperative can serve only a fraction of its own members' land. After allocating a season's irrigation (less than 5 acres), if there is spare capacity left, additional irrigation is offered on request. Non-members take only a rainfed kharif crop, so do members on whose land falls outside the command of the system. During a drought year,

8 *Headman.*

many members find their relatives from saline areas camping with them in search of fodder. During the drought, the cooperative suspended normal cropping patterns and everyone grew only fodder; the cooperative also provided water to non-members to grow fodder. This helped the village and many other families from the saline areas to survive the drought.

Members also have private wells on their fields within the command, and, according to Arjanbhai, there are no formal restrictions on pumping in summer. In kharif and the early part of rabi when there is some fresh water recharge, farmers pump their own wells, which is safe. In summer, no member pumps his well since everyone knows that it will affect their soil. If this is true, it supports the point that some self-regulation can be generated with an effective supply side intervention.

## 3.7 Options

There are two ways Husseinabad and other villages in the area suffering similar conditions can go. First, without a major initiative to change the current trend, it would take between 3-10 years or 2-3 drought years before the entire village land becomes saline. In this event, the farm output and employment would decline to about a 10th of the present level and majority of the population will be pauperised and have to shift elsewhere to seek a livelihood. The second option is for a new ecological equilibrium to be established in the village through: (a) effective enforcement of checks on the withdrawal and wasteful use of groundwater; (b) planned efforts to increase recharge and harness rainwater in surface structures; (c) import of fresh water from points further inland without disrupting the groundwater balance there; and (d) changing to crops which can require modest amounts of fresh water or which tolerate saline water.

Of these, (b), (c) and, to some extent (d) which would require extensive interface with agricultural research establishments, could be undertaken by institutions like the AKRSP. These will, no doubt, delay the worst consequences by a few more years, but as current experience with government programmes has suggested, the slack created by (b) and (c) will most likely get used up by farmers who increase their irrigated area rather than establishing a new ecological equilibrium. For this, the village community needs to evolve demand side interventions which involve making and enforcing new rules of the game.

The responses we received to suggestions about demand side interventions was usually luke warm and often outright negative. Those whose wells have fresh water still would have no part of it; those whose wells do not, just do not care. Professor Bromley suggested that compliance to some rules and norms be the pre-condition to AKRSP involvement in the village, and this might work if the village community believes that AKRSP can deliver something substantial for each of them, or if enthusiastic community members believe it would improve community prospects, and they can sacrifice time and energy, and are willing to commit themselves in the cause.

## 4 LESSONS

For the next ten years or so, the Amrapur problem can be largely resolved by an assortment of physical structures that AKRSP can put up to retain and increase the recharge of wells. Likewise, in Husseinabad, conditions can be temporarily improved by the AKRSP rehabilitating the old canal and using it as a source of fresh recharge. But what is more important and useful is understanding how the village communities can, with some outside support, develop their own internal capacities to cope with such problems and to institute ***self-correcting mechanisms*** (SCMs). What would also be important and useful to understand are ways in which macro level policies - legal, infrastructural, and others, might support the development of such localised self-correcting mechanisms.

SCMs might involve internal mechanisms for equitable regulation of water use or developing new sources of fresh water, or both. In either case, some form of community organisation would be needed with a widely acceptable authority structure.

Present experience suggests that, on their own, it is highly unlikely that such SCMs will evolve except where leaders like Arjanbhai apply themselves to such problems. Although studies which attribute local successes to capable local leaders may lead one into a blind alley, in our field work we came across several young people who might well be the 'Arjanbhais' of their respective villages if only being a leader did not impose a high personal cost in terms of resources, time and effort. This cost means that besides being willing and able to assume the leadership role, the potential contender must be so well off and ably supported that he can afford to delegate his personal affairs. In the course of our discussions, Bromley mentioned the importance of restoring traditional local authority structures for better management of common property resources. It is doubtful if this is possible in these villages; but it certainly seems within the realm of possibility to draft more potential leaders into the task of creating SCMs by reducing the personal cost of assuming leadership. Experimentation alone can help us identify how best to do this; and NGOs like the AKRSP might take a lead in this regard.

Given the presence of good local leadership, the process of community organisation around water management issues can be best started by involving water user groups in understanding the technical behaviour and relationships of between wells and recharge sources. Such shared understanding can form a sound basis for community planning and management of the water resources. Individual involvement can be strengthened if this also improves their understanding, and thus the use of their own wells helps them understand better and to use it more creatively. In the process, mechanisms should be created for new knowledge to be shared with other well owners. Over time, such a process would heighten the awareness among well owners of the various inter-dependencies and the opportunities for better community management of water resources. Such a process would also be essential to community initiatives in (a) identifying new sources of recharge and surface water and raising resources to develop them; (b) evolving and enforcing mechanisms for equitable regulation of water extraction and use, and (c) optimal water use planning. The scheme such as one outlined earlier for Amrapur may eventually result in such community initiatives and 'self-correcting mechanisms'.

Macro level policies can support or discourage the emergence of SCMs and individual behaviour that accentuates the problem. For instance, a flate rate charge for power may encourage profligate use of water because the incremental pumping costs under flat power tariff becomes very low. In principle, the options here are: (a) to switch to pro-rata power charge; while this will make water costlier to lift at the margin, it will by no means guarantee regulation of water use to the desired level, or (b) continue with the flat power price regime but use judiciously planned restrictions on power supply for pumping so as to limit water extraction to desired levels. There are many operational and political issues involved in this; but power supply and pricing policies can be a potent instrument of groundwater regulation in the type of areas represented by our two villages.

Legal interventions too can, in principle, help. In Burma, for example, a 1930 groundwater act is believed to have effectively regulated the rate of establishment of wells in areas through a system of licensing. In India, however, most researchers and development practitioners have serious reservations about the enforcement of groundwater laws. Experience with the implementation of siting and licensing norms, in force in most states, support these doubts. In Gujarat, for example, a groundwater act passed in the assembly over a decade ago has yet to be made into a law. Political opposition is likely to be another factor that may reduce the effectiveness of legal interventions.

In the long run, large-scale planning of water resource development must recognise the high returns from bringing surface water to coastal areas with fragile aquifers. It is an irony that mega-projects like the Narmada should increase surface water supplies in areas like Kheda, Baroda, etc, which already have good groundwater surface water resources, while additional surface water supplies are so badly needed in coastal Saurashtra.

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